Breaking News:
Turbulence observed using Range-imaging with the EAR

4-frequency observations of Troposphere and Stratosphere

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Background to Radar Imaging

- Super-resolution technique
- Scan power distribution in beam volume
- Range imaging uses multiple frequencies
- Minimum step determines grating lobes
- Maximum step determines main lobe
- Number of steps affects side lobes and improves statistics

OBJECTIVE:

- to learn more about turbulence, waves and other atmospheric dynamics through remote sensing of trace parameters that allow us to infer the parameters of interest.

⇨ What we actually want is an in situ instrument capable of giving us the information we want directly. Such as high-resolution balloons, hot-wire sensors, etc.

Direct measurement of gravity wave instability by in situ sensor

Ocean surface (wind-driven)

Out-flowing ocean from coral reef

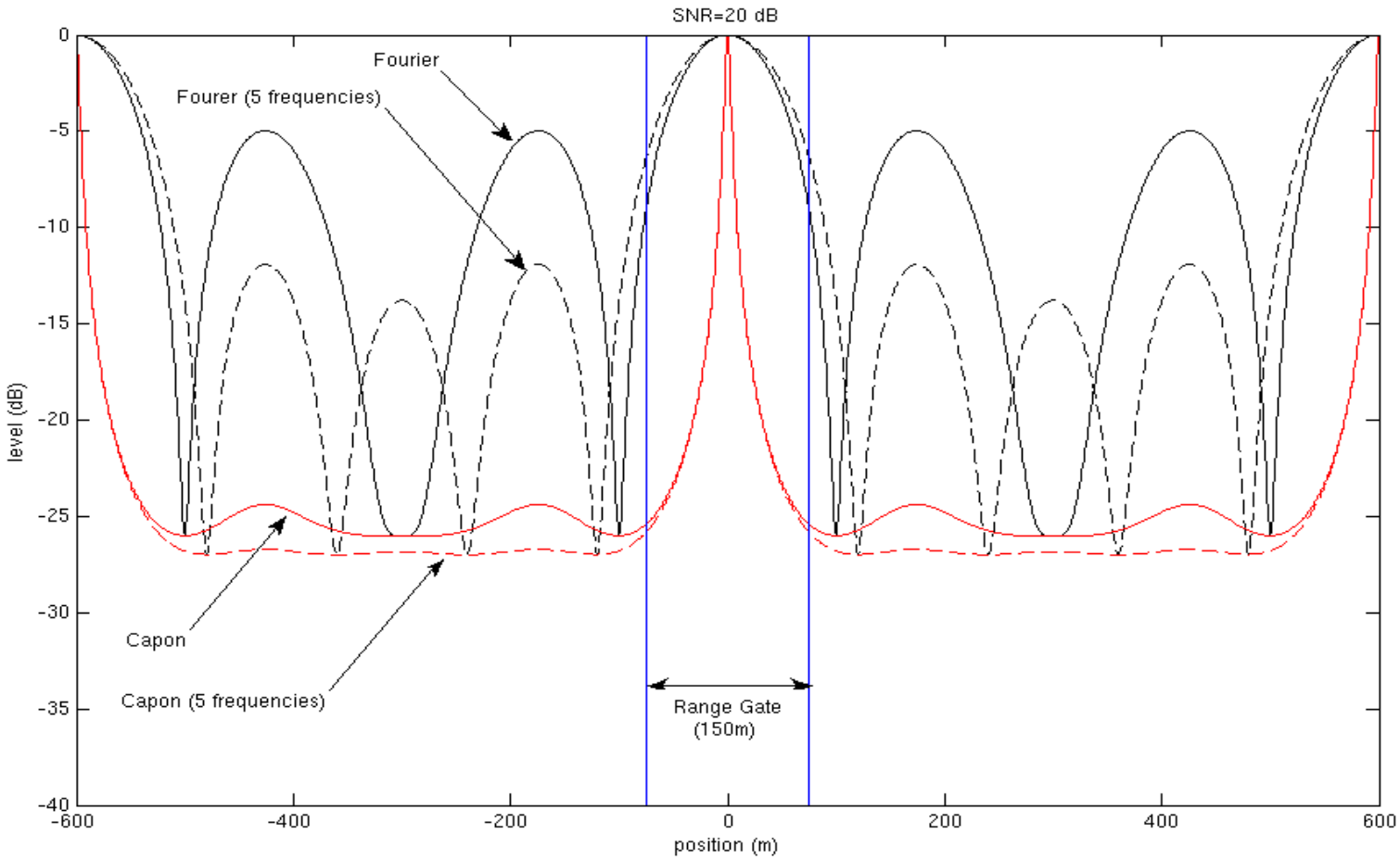
Stable layer (reef < 1m) acts as buoyant force for shearing ocean

Tahiti – Surfing spot with the fastest wave in the world. Name: “Broken Skulls”

Imaging with the EAR

- 4 frequencies: 46.5, 46.75, 47.25, 47.5 MHz (4 steps available: 0.25,0.50,0.75,1.00 MHz)
- Bandwidth: 1 MHz
- Non-uniform steps: 0.25--0.5--0.25 MHz
- This brings up the side lobes slightly
- Minimum step: 0.25 MHz
- Puts grating lobes outside of 150-m gate

Model EAR Range Imaging Function



(RED solid) Model of Capon imaging filter function for SNR>20dB, using 4 frequencies 46.5, 46.75, 47.25, 47.5 MHz and vertical beam with 150-m pulse-width. The side lobes are placed outside the range gate. (RED dashed) Comparison with model using 5 evenly-spaced frequencies, showing how the side lobes are lower.

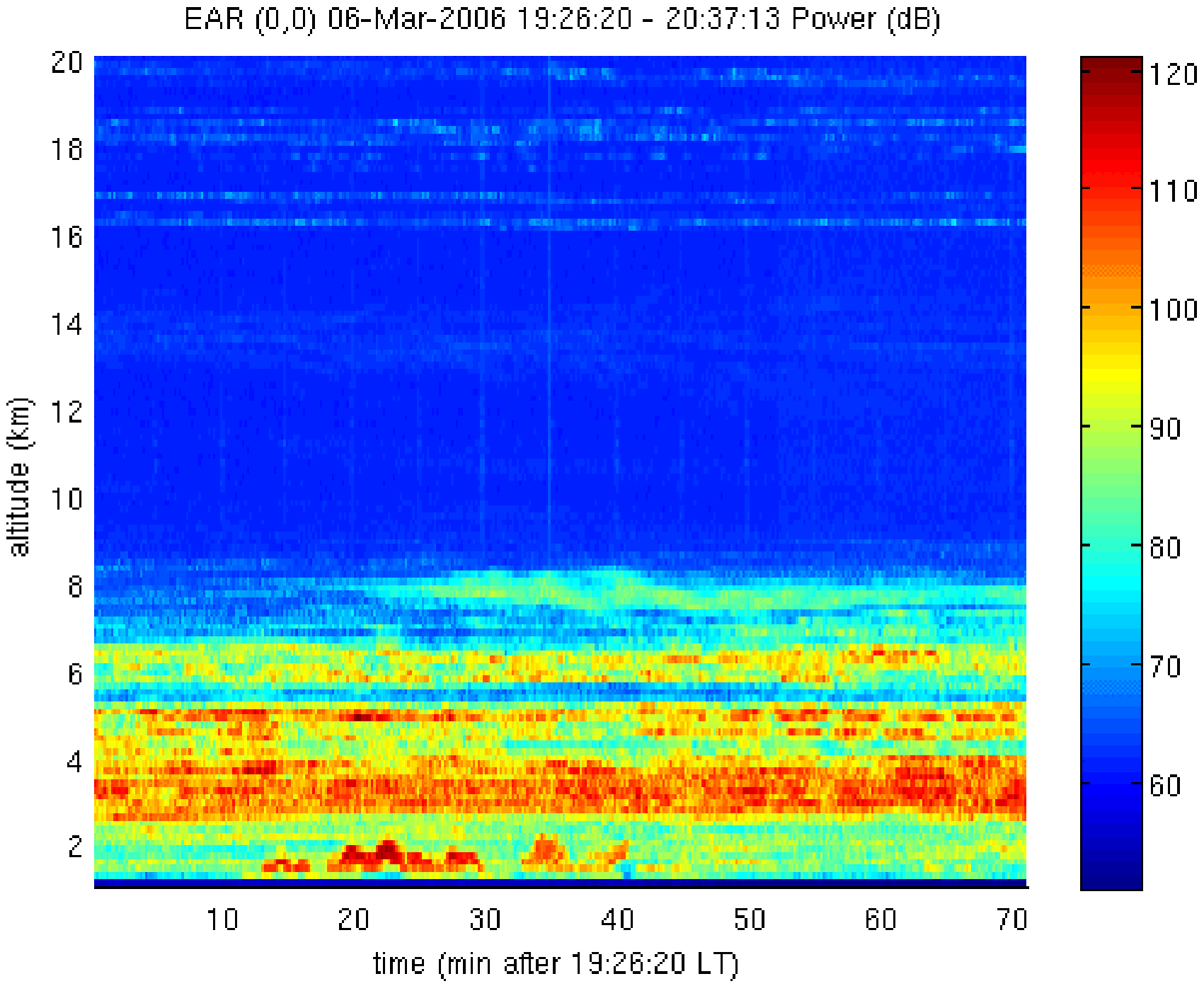
Experiment 6 March 2006

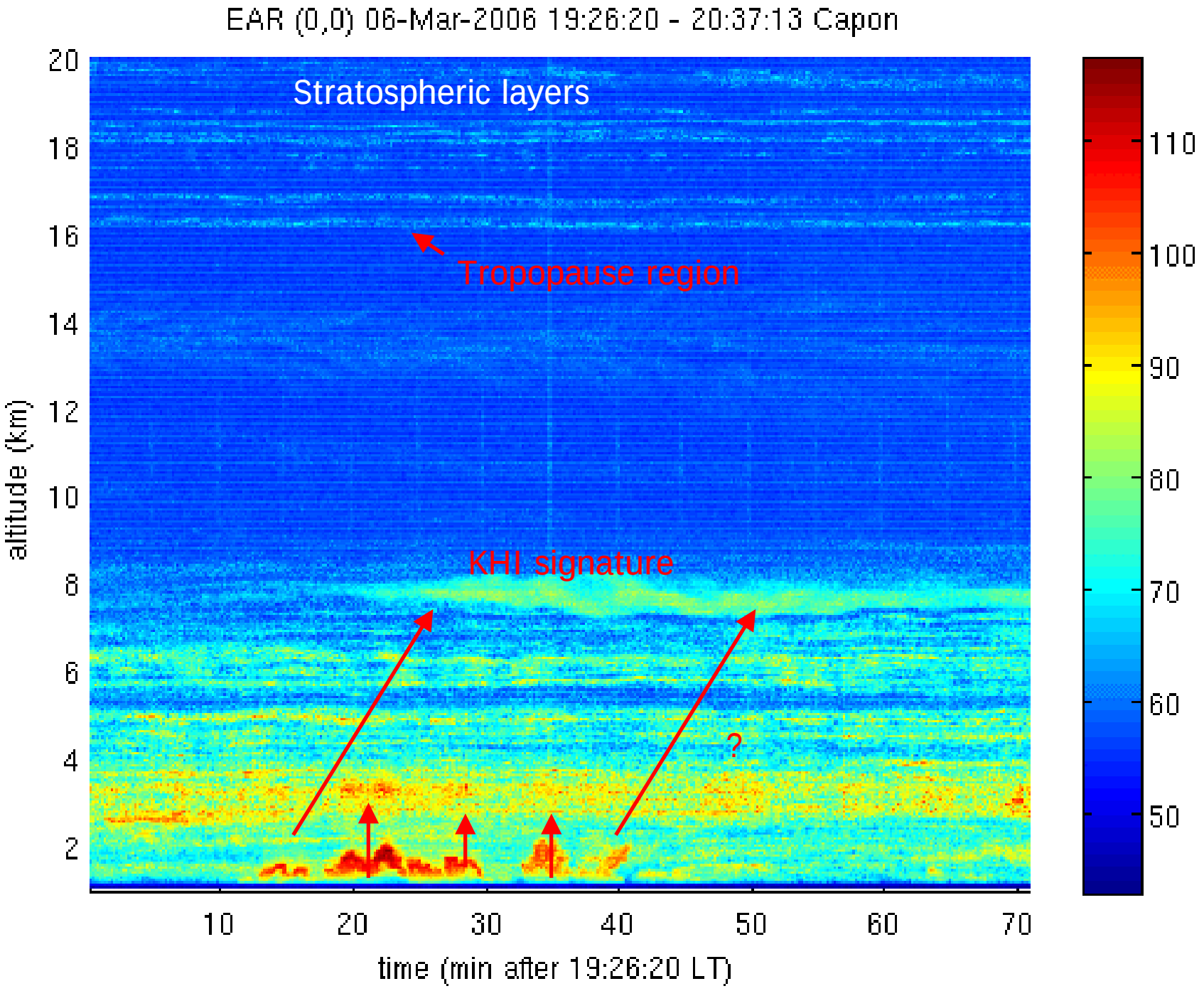
Objectives:

- test 4-frequency FII mode, using 150-m and 75-m gating
- Use 1 vertical beam, and try 2 beams (1 vertical, one oblique)
- Use continuous sampling to obtain long records for flexible post-processing.

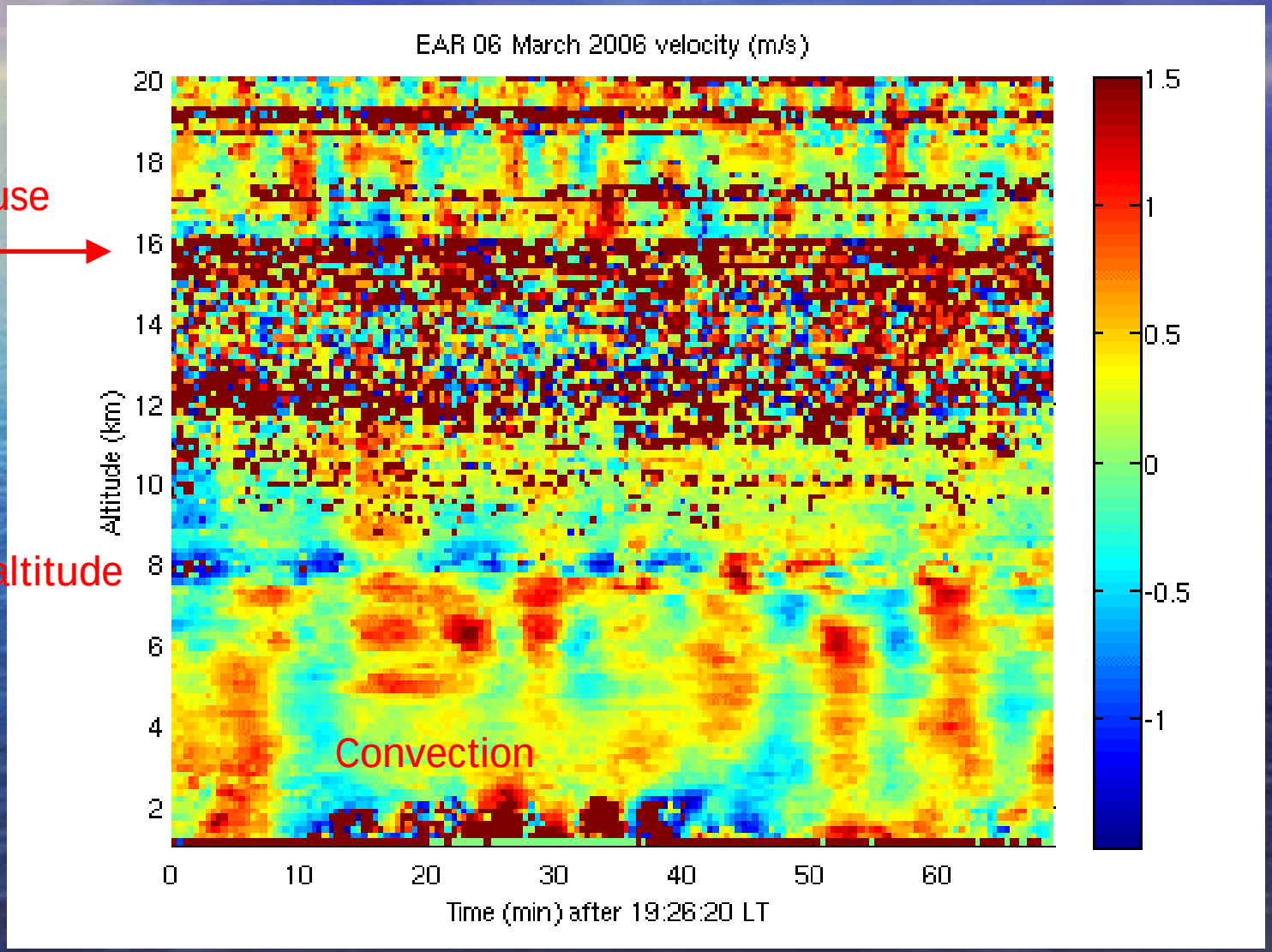
Parameters of observation used in this presentation

- Beams: 1 vertical
- Frequencies: 46.5, 46.75, 47.25, 47.5 MHz
- Altitude: 1.05 – 20.1 km (128 x 150m)
- Coding: 16-bit Spano truncated coding
- N_{coh}=128 (each point=0.0512 sec)
- N_{fft}=4096 (but continuous for 5 records)
- N_{incoh}=1 (!)

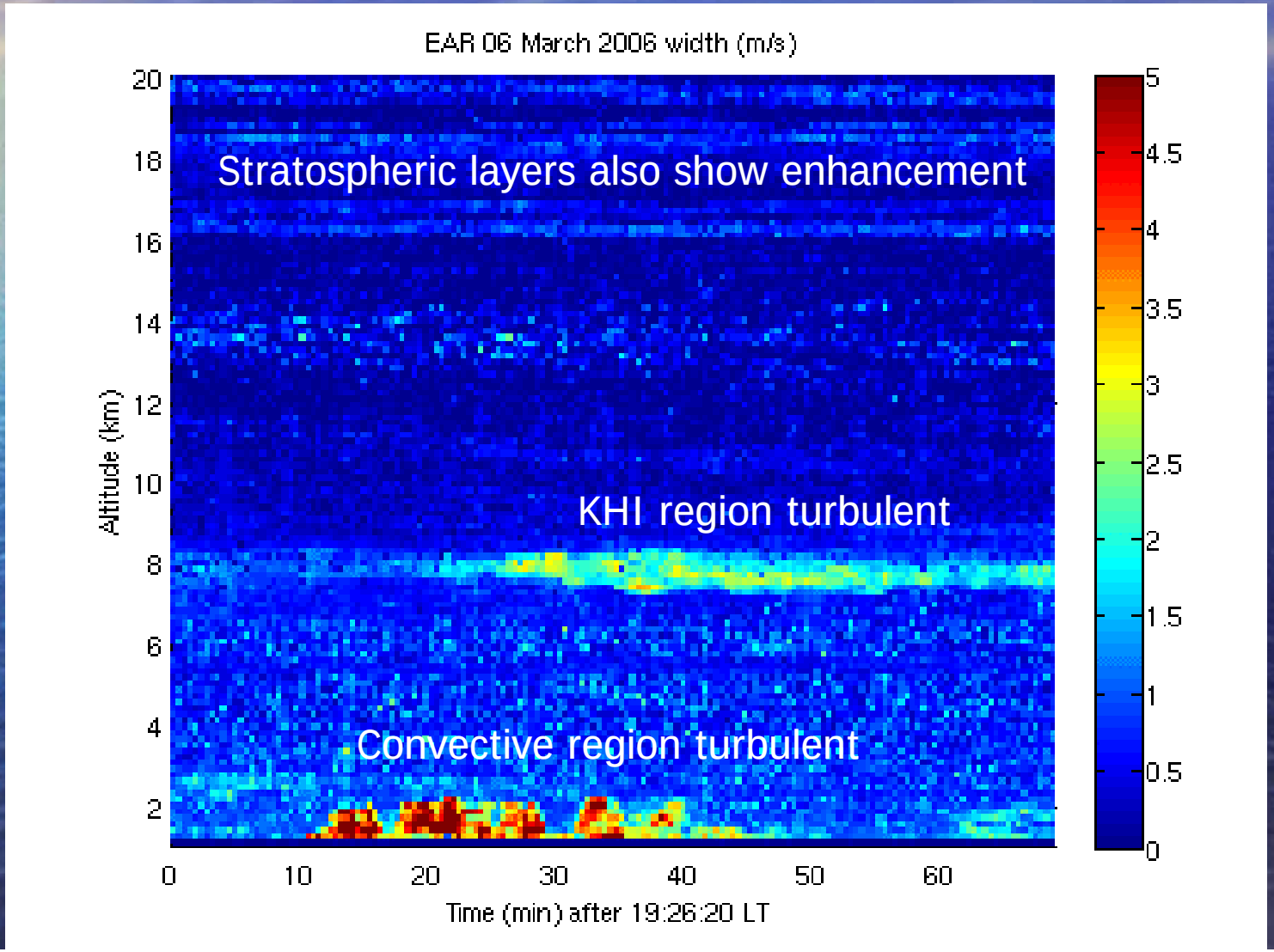

EAR (0,0) 06-Mar-2006 19:26:20 - 20:37:13 Power (dB)
altitude (km)
20
18
16
14
12
10
8
6
4
2
10
20
30
40
50
60
70
time (min after 19:26:20 LT)
120
110
100
90
80
70
60


EAR (0,0) 06-Mar-2006 19:26:20 - 20:37:13 Capon
Stratospheric layers
Tropopause region
KHI signature
?
altitude (km)
time (min after 19:26:20 LT)
20
18
16
14
12
10
8
6
4
2
10
20
30
40
50
60
70
110
100
90
80
70
60
50

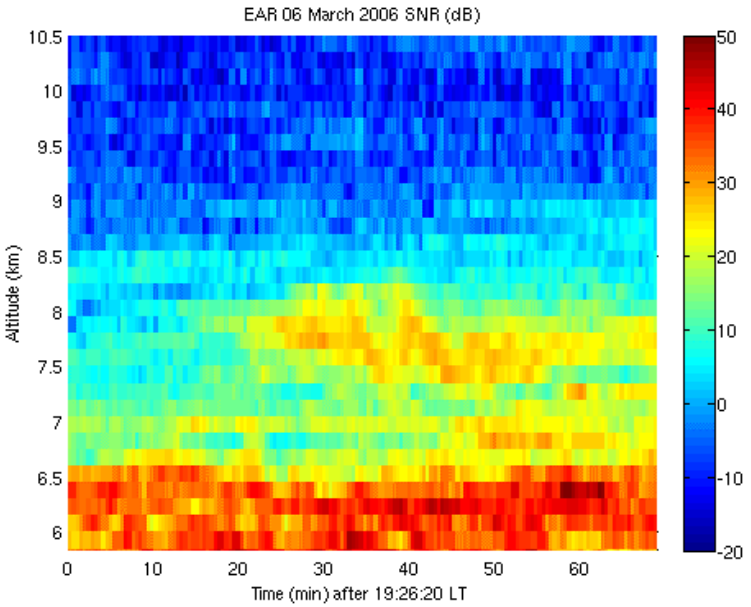
Vertical Wind (Hubert Luce)



Spectral Width (Hubert Luce)

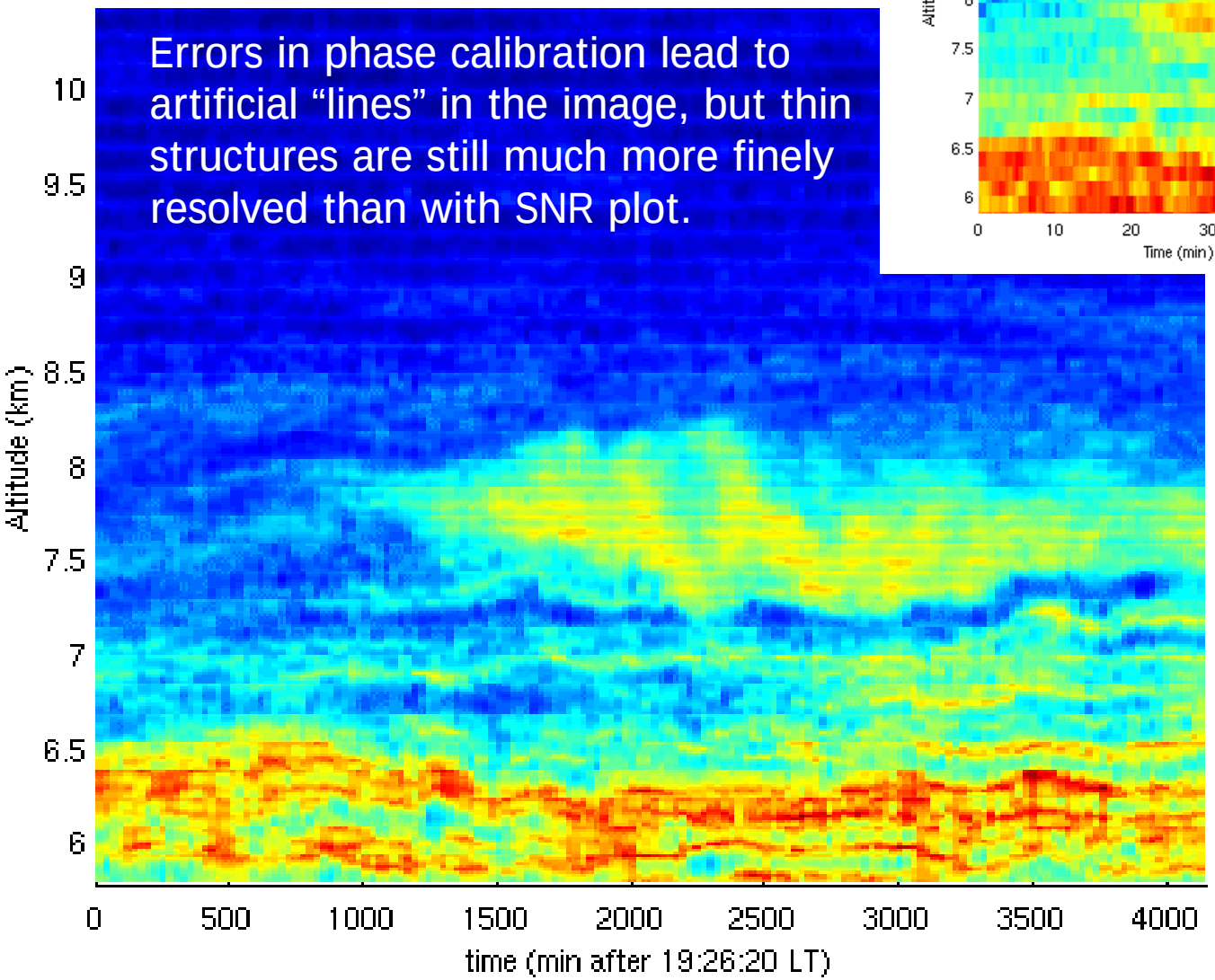


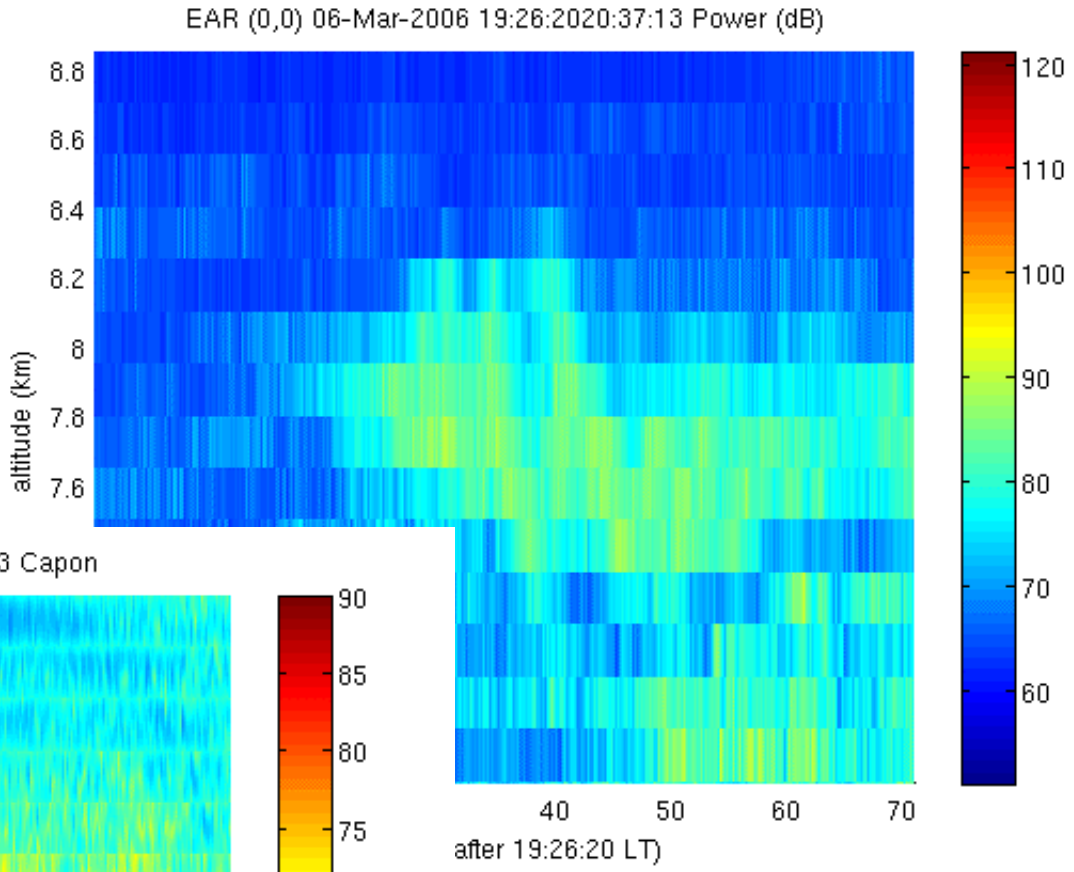
Comparison of Power (SNR) RTI plot (right) with Capon Image RTI plot (below).

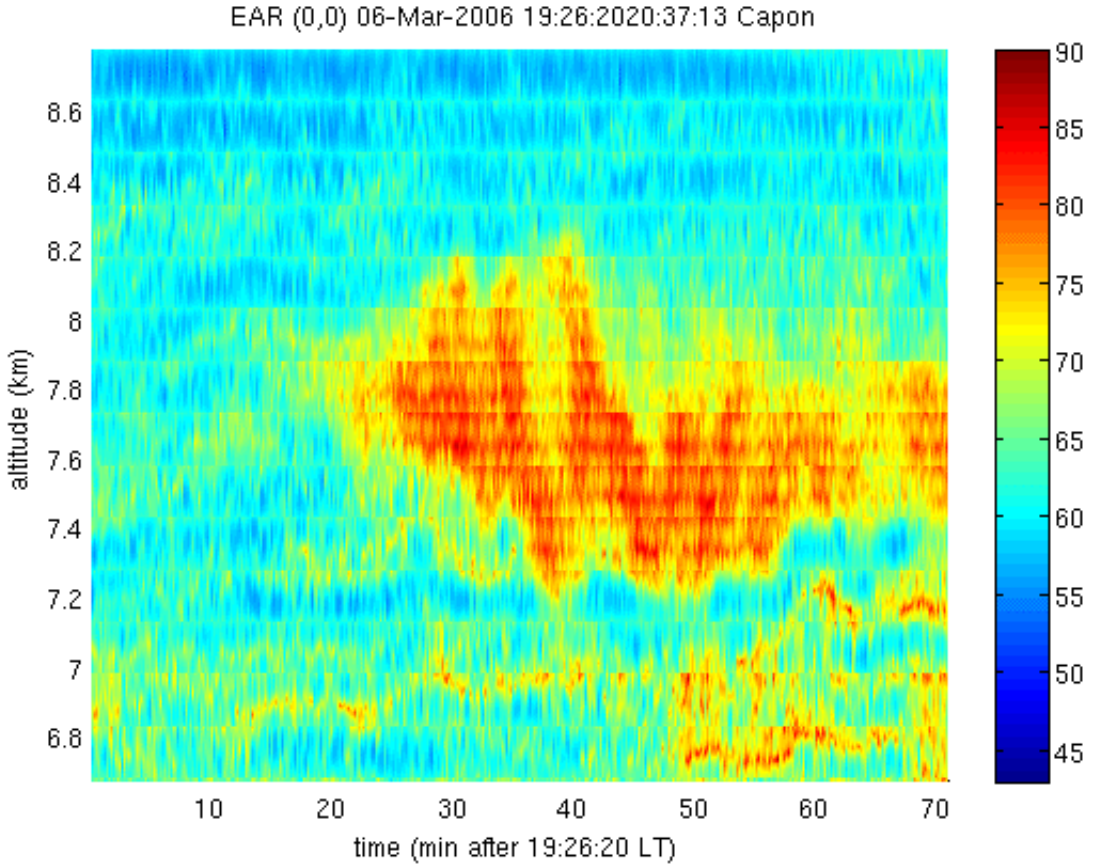


EAR 06 March 2006 19:26:20 LT FII: Capon

Errors in phase calibration lead to artificial “lines” in the image, but thin structures are still much more finely resolved than with SNR plot.



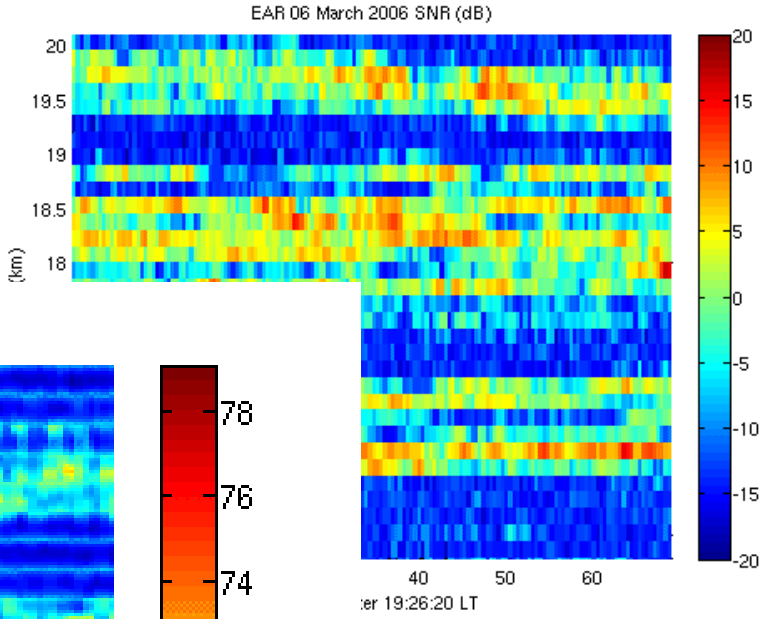


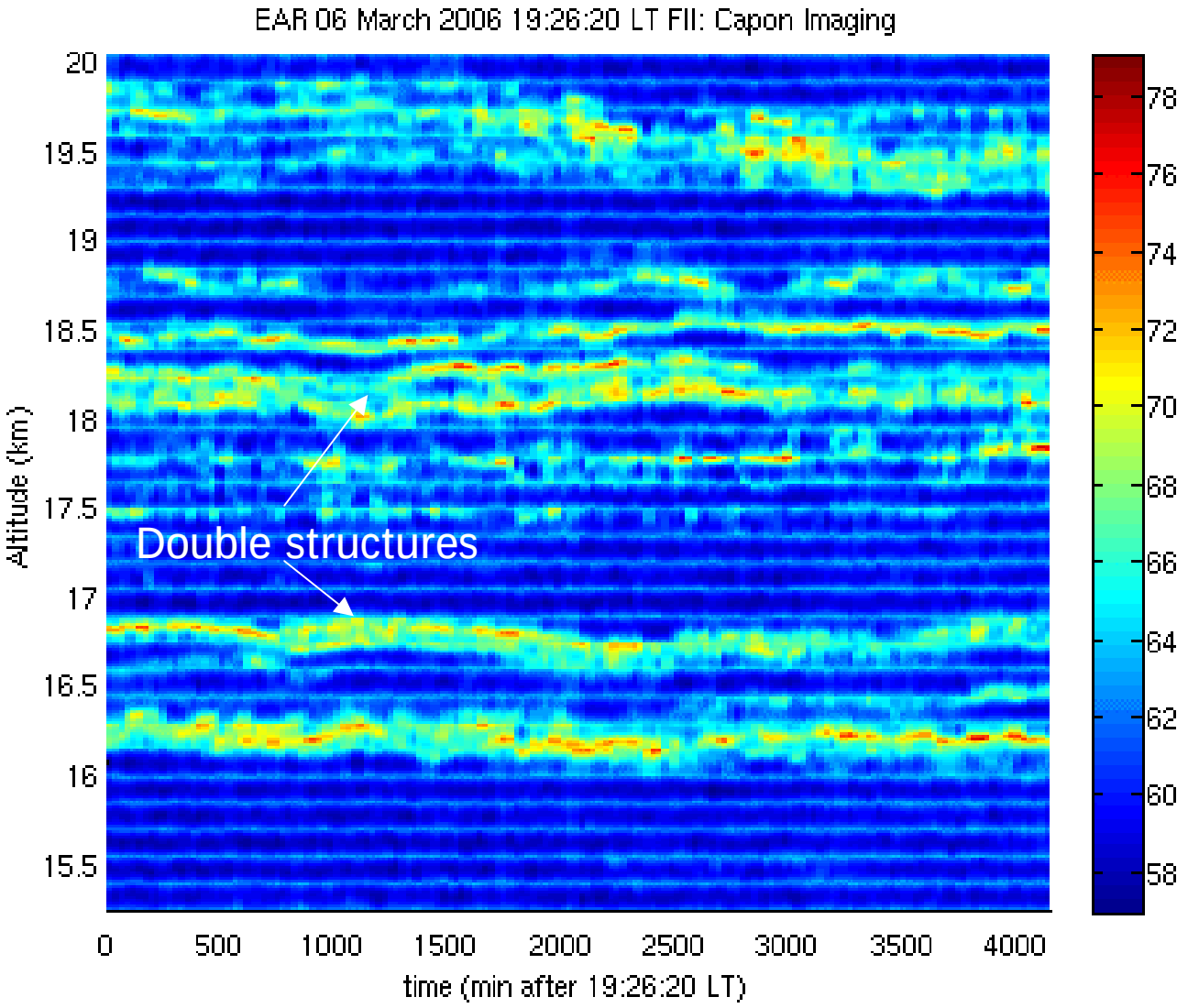


"lines" in previous example:
It appears that part of the Range gate shows increased Signal, position depending on the frequency correction of the 1-MHz phase difference Histogram.

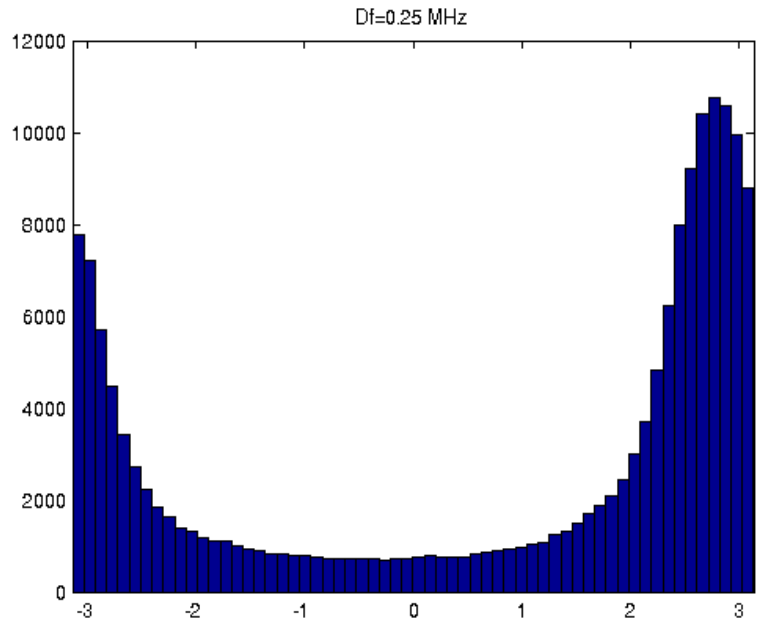
Stratospheric layer structure imaged with Capon method (below) compared to SNR plot (right).

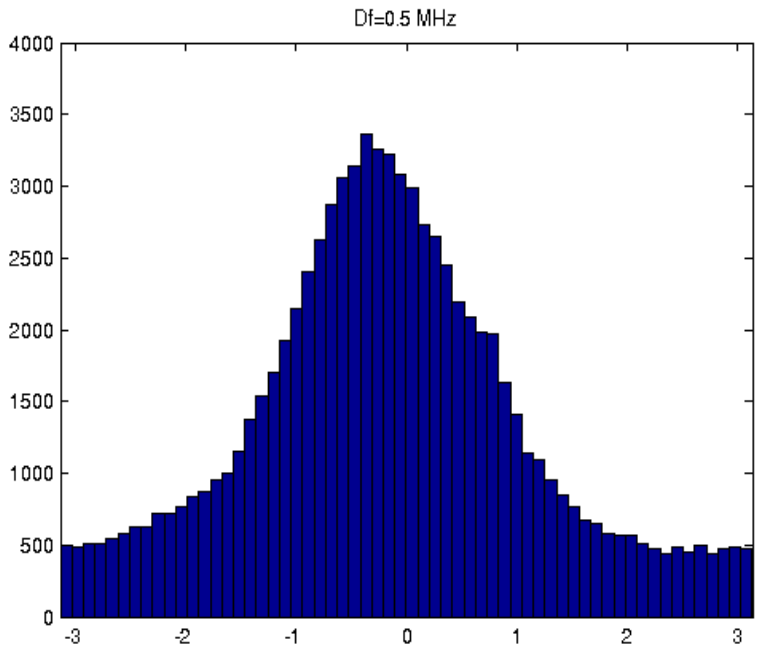
At higher altitude the phase calibration error seems to have less impact.

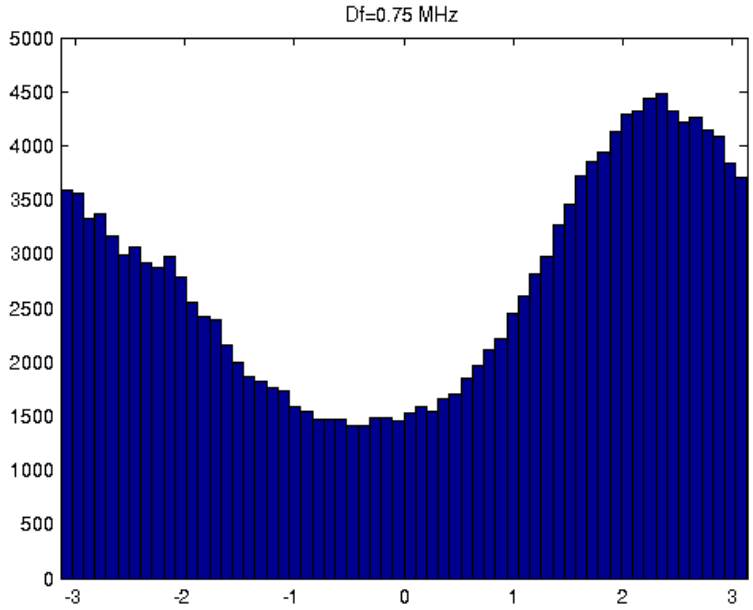




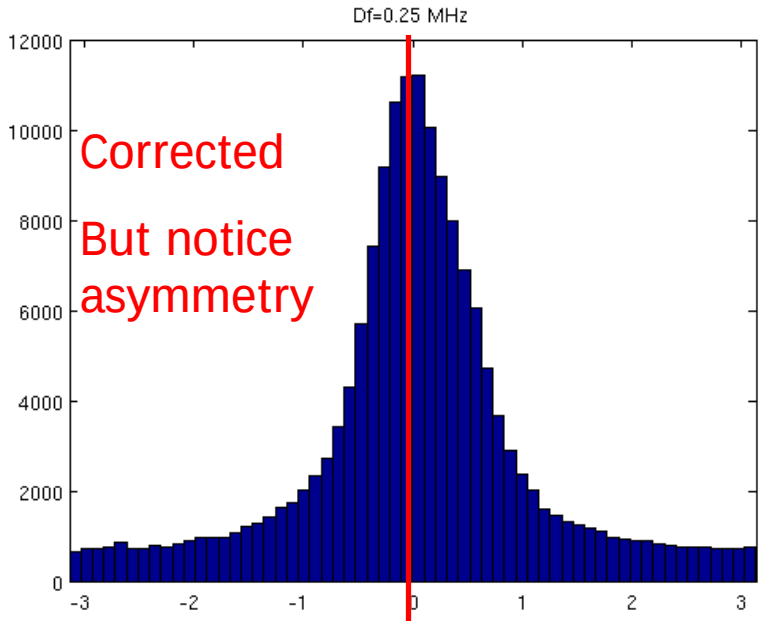
Phase histograms for the 4 frequency differences 0.25, 0.5, 0.75, 1.00 MHz

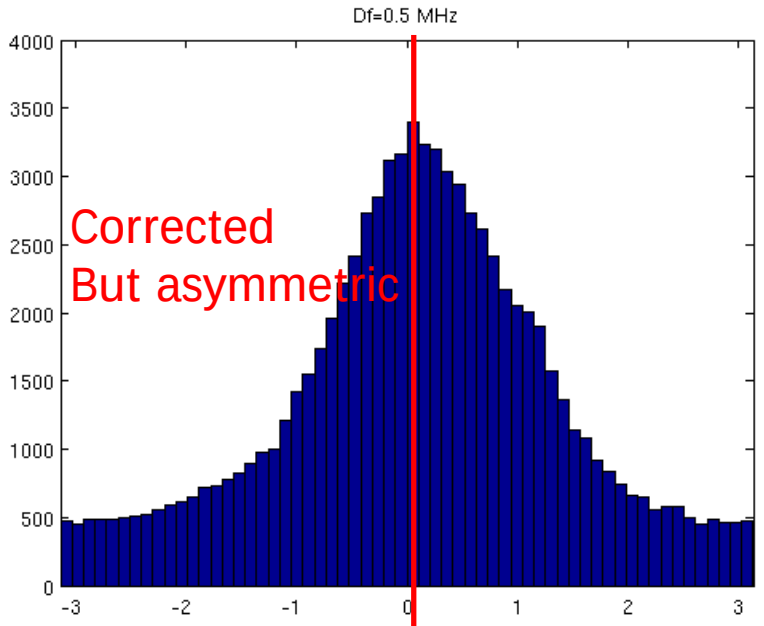


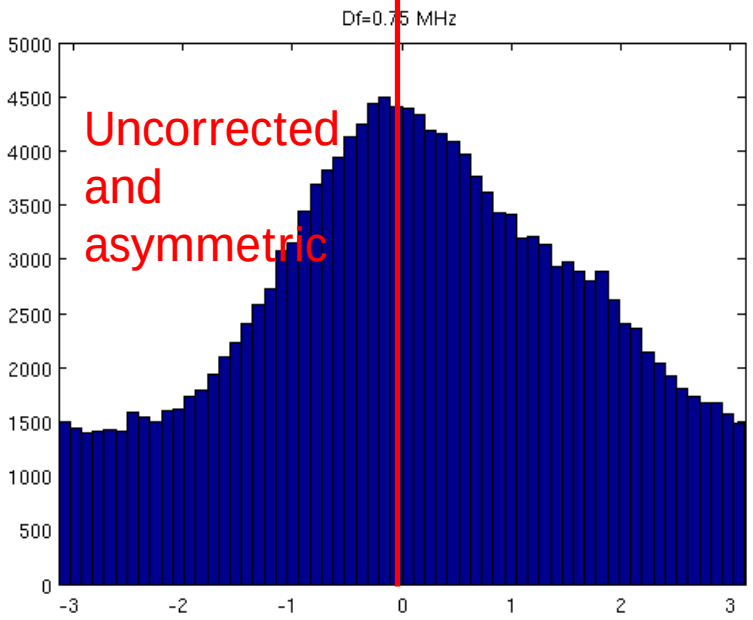


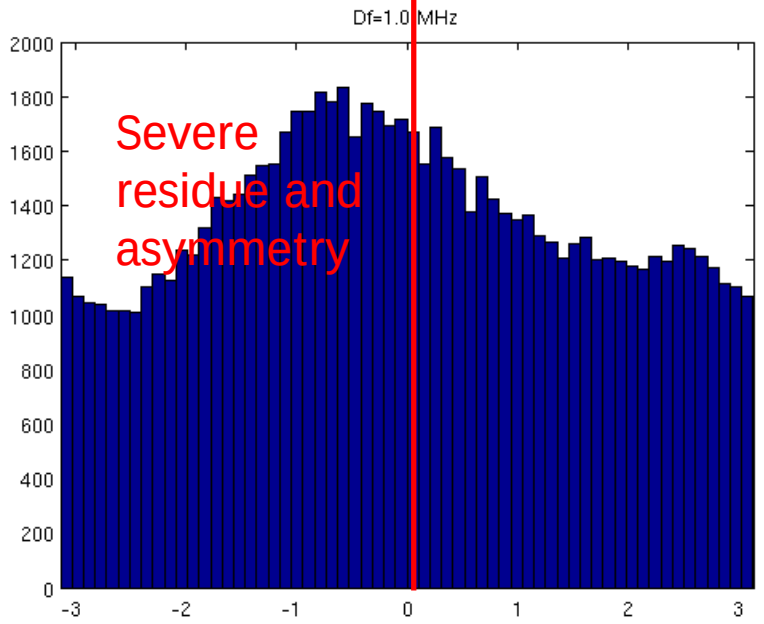


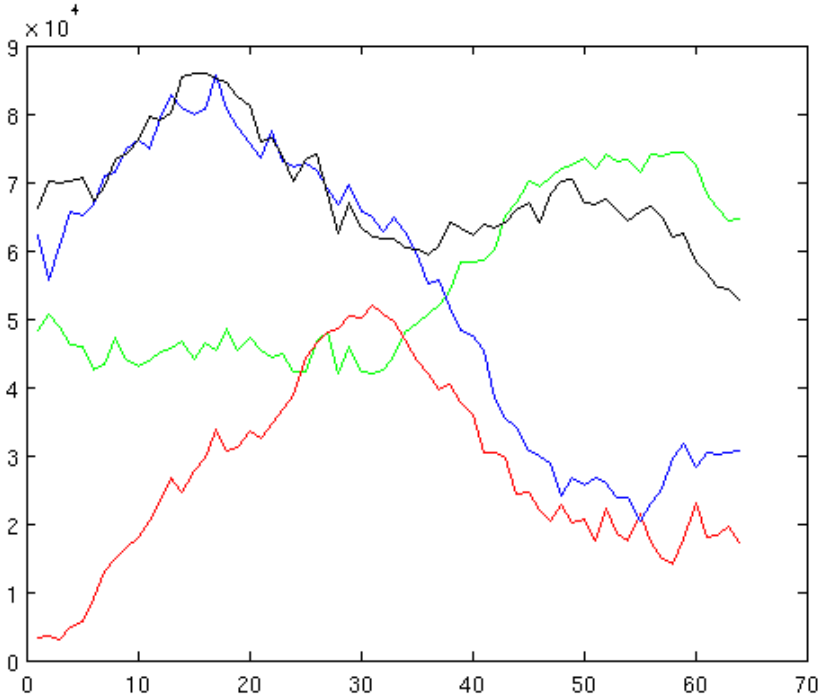
Corrected phase – 2 methods give virtually identical results





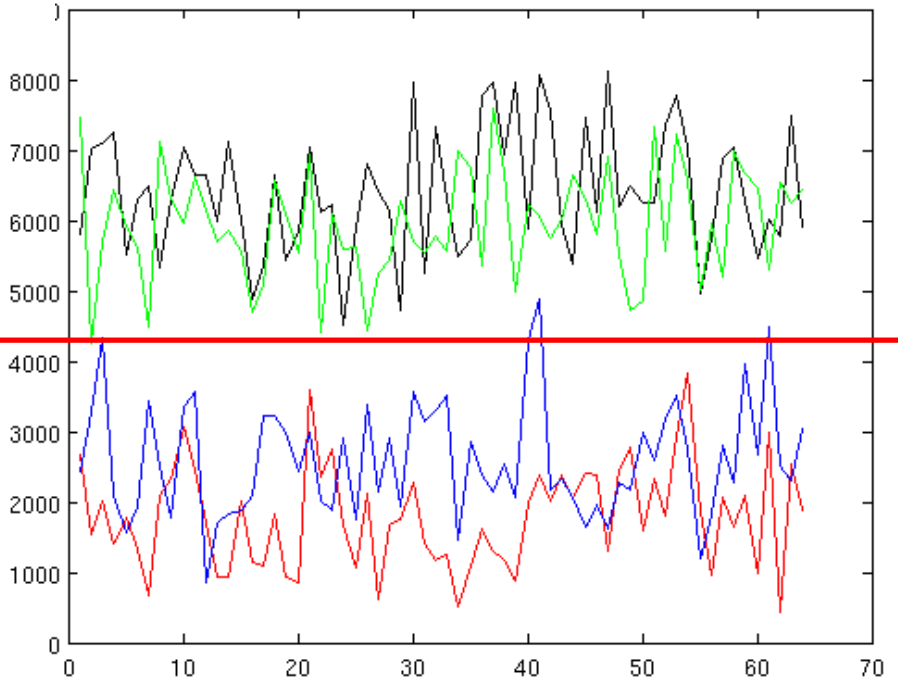






Auto-Correlations of 4 frequencies at Gate 10 (2km) where strong signal is present, at time of convective events (20H00)

Same but for gate 75 where no signal is expected



Discussion

- Imaging quality poor due to possibly receiver (Bessel filter) distortion effects for frequencies far from 47 MHz (Hubert Luce).
- Higher sidelobes for non-equal spacings may also have detrimental effect when many layers are in close proximity (low altitude).